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The ICT Revolution: Opportunities and Risks for the *Mezzogiorno*

Summary

The question of the spatial impacts of Information and Communication Technology (ICT) has animated intellectual and policy debate for a long time. At the beginning of the 1990s the advent of the Internet brought a new surge of debate: it was argued that the Internet would free the economy from the constraints of geography (Cairncross, 1997), bringing about a more even economic landscape. New opportunities seemed to arise for the poor regions in peripheral areas such as the Italian *Mezzogiorno*.

However, this contrasts sharply with the popular view of, for example, Silicon Valley, a congested area where world-class ICT and high-tech industries cluster together.

In theory, geographical agglomeration of economic activities results as an equilibrium solution of a tension between centripetal and centrifugal forces. ICT has the potential to alter the balance between centripetal and centrifugal forces and therefore the final equilibrium solution. Literature shows that, from a theoretical point of view, there are a number of counterbalancing effects rather than a one directional trend. The question therefore begs empirical research.

This paper investigates the effect of the ICT revolution on industrial locational patterns across Italian provinces. It shows that the increasing use of ICT in the economy may indeed lead to greater dispersion of economic activity, i.e. less regional disparities. On the other hand, there is evidence that the parallel shift towards more knowledge- and skill-intensive activities might counterbalance this dispersion effect.

Keywords: ICT, Regional cohesion, Convergence

JEL: R0, O3

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Introduction

Continuous technological progress in ICT – starting with the introduction of the transistor back in the 1940s – has speeded the codification, processing, storage and communication of an ever increasing mass of information. Individuals can now communicate instantly with people never met, send the information contained in a book anywhere, and almost immediately, as well as listen to any type of music produced in the world. Businesses are able to create and maintain large, centralised databases and share this centralised knowledge-base with decentralised operational plants. Workers can work remotely from their offices. The scenario is one of great changes in transport and communication costs.

Over a century ago, Alfred Marshall (1890) wrote that "*Every cheapening of the means of communication alters the action of forces that tend to localise industries*".

What does it imply now? What are the consequences of the ICT revolution on the spatial organisation of economic activities? More in particular, will ICT bring new opportunities to peripheral regions?

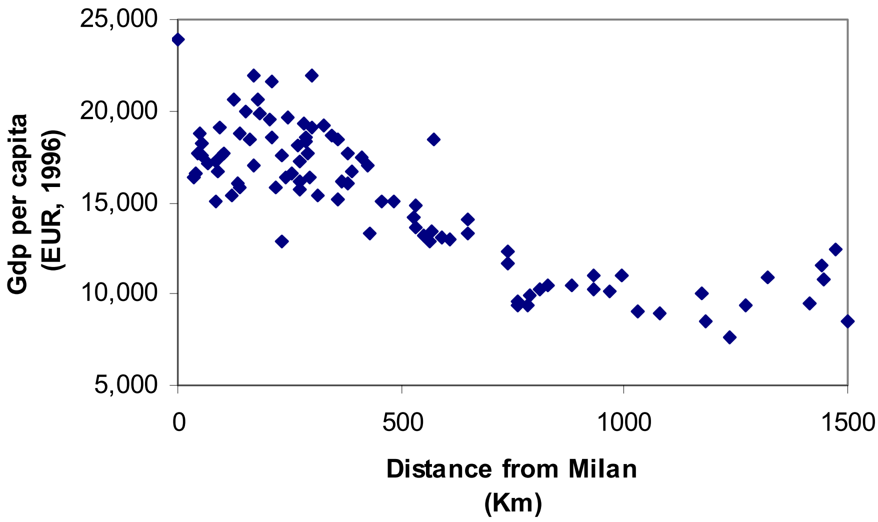
These questions have animated the intellectual and political debate for a long time. In 1964 Marshall McLuhan wrote that new technologies would lead to a 'dense symphony of nations', with activities leaving the centre and going to the periphery, to create a uniform 'global village'. In 1988 Bairoch suggested that one of the causes of urban sprawl (in his words the 'break up of cities') was the development of television.

The beginning of the 1990s, following the emergence of the Internet, saw a new surge of debate. It was suggested that the Internet would free the economy from the constraints of geography. The Internet was perceived to be 'everywhere, yet nowhere in particular' (Economist, Aug 2001). Since ICT products are 'disrespectful of physical distance and geographical barriers' (Quah, 2000), the digital revolution could bring about the 'death of distance' (Cairncross, 1997): just as 'weightless' goods such as software, databases, electronic libraries and new media can be transported at no cost, and workers are free to work anywhere, so the digital economy should promote development opportunities in more remote and economically disadvantaged areas. The impact would not only be felt in new industries, but also in those traditional industries that would benefit from improved access to world markets.

This view seems to contrast sharply with most of our historical and everyday experiences. In the XIX century, there were some 250 stock exchanges in the US, serving local markets. The introduction of the telegraph tranformed the NYSE from a local into a national exchange. Nevertheless, communication remained costly and the Hartford Stock Exchange was able to compete successfully with New York until 1933, when a long distance line was installed. Within two years the Hartford Exchange closed (Cambridge Econometrics, 1997, p 35). Nowdays, Silicon Valley concentrates world-class ICT and high-tech industries in a very congested, compact area. In both cases, ICT has appeared to result in greater concentration and to further advantage the position of more developed cities and regions.

The aim of the present paper is to contribute to the foregoing debate by investigating the impact of ICT on the economic geography of Italy. Italy is an interesting case because of its division between a highly developed North and a much less developed South. This is the so-called *Questione Meridionale.* Figure 1 shows graphically the *Questione Meridionale:* provinces (NUTS 3 regions) farther from the Italian core of economic activities (here exemplified by Milano) have lower income per capita. Indeed, some southern provinces have a level of income per capita which is around a third of the level in Milano and Bologna.

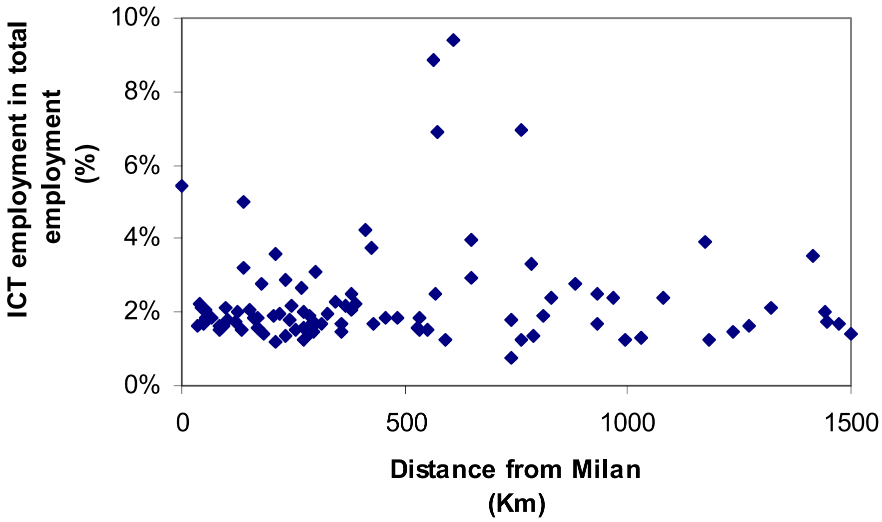
Figure 1: Peripherality and income per capita across Italian provinces



This polarisation of the economic landscape has been there since the unification of Italy, in the XIX century. The divide has persisted until now, despite strong policy intervention. Whether ICT will smooth or reinforce current divide is therefore a crucial issue for Italian policy-makers.

Indeed, Figure 2 shows that the spatial distribution of ICT production does not exhibit a clear north-south divide and this might affect the overall distribution of economic activities.

Figure 2: Peripherality and ICT-specialisation across Italian provinces



Section 1 introduces the theoretical background. It discusses the forces (centrifugal and centripetal) that shape economic geography and how they are altered by the increasing use of ICT. Section 2 reviews the existing empirical evidence. Section 3 analyses industrial concentration patterns in Italy. Section 4 carries out an econometric analysis of industrial convergence. Section 5 draws the conclusions.

1. Theoretical background

Current economic literature has explained the type of agglomeration patterns that characterise the spatial distribution of economic activity in space, in terms of a balance between some centrifugal and centripetal forces.

Agglomeration results from some forms of increasing returns that induce cumulative causation mechanisms to set in and lock development processes. In fact, the sheer notion of "location decision" by a firm contains an implicit assumption of increasing returns (i.e., of costly duplication of the firm's production process in different places). Under constant returns to scale, firms do not need to choose where to locate: they can disperse arbitrarily fine operations plants anywhere in the territory (Quah, 2001b).

Marshall (1890) has described the three main *centripetal* forces (Marshallian triad) that are at the base of the existence of agglomeration. We briefly summarise them below following Krugman (1998):

- Market-size effect (demand and cost linkages, also called backward and forward linkages). A local concentration creates a large local market that in turn creates both '*demand linkages'* -: sites close to large markets are preferred location for the production of goods -; and *'cost linkages' -:* the local production of intermediate goods lowers the production costs of other producers;
- Thick labour markets. A local concentration supports the creation of a thick labour market, where employees and employers are readily matched;
- Pure external economies. A local concentration creates information spillovers benefiting all firms in the agglomeration ('The mysteries of the trade become no mystery, but are, as it were, in the air' (Marshall, 1890). Besides, it is easier to monitor and manage activities in an established centre where firms know and can benchmark each other performances (Venables, 2001).

If only centripetal forces were at work, the final result would be a unique agglomeration of economic activity. Opposing to that and limiting the otherwise indefinite possibility of growing of the agglomeration are the *centrifugal forces,* all of them involving some form of costly transportation or congestion costs. The set of *centrifugal forces* is more difficult to complete. Krugman (1998) suggests the following useful classification:

- Immobile factors. Immobile factors (land, natural resources, and, to some extent, labour) slow down the process of agglomeration, both on the *demand* side (industries have to go where factor owners are) and on the *supply* side (industries have to go where factors themselves are);
- Land rents. Concentration of economic activity drives up the cost of land and disincentivates further concentration. This explains, for example, why most of the land-consuming manufacturing activities have left the urban areas;
- Pure external diseconomies. Concentration of economic activities and concentration of population are likely to lead to increased traffic, congestion, pollution and crime.

The digital economy is dramatically reducing transport and communications costs. It has therefore the potential to alter the current equilibrium of centrifugal and centripetal forces, and to re-design the existing economic landscape. The final effect is not self-evident. Table 1 summarises some examples of possible channels through which those effects can come about (a fuller discussion can be found in Maignan et al, 2003. Most of these effects are originally discussed in Venables, 2001).

Table 1 How the digital economy changes centrifugal and centripetal forces

Costs affected by the rise of the digital economy	***Effect on centrifugal and centripetal forces***	***Explanation***
Reduction in search and matching costs	Strengthens centrifugal forces	Reduction in costs of searching and finding trading partners
Reduction in direct shipping costs	Strengthens centrifugal forces	No need to locate close to producers or other ICT firms as transport costs fall
	Strengthens centripetal forces	No need to follow dispersed customers
Costs of personal interactions: relative roles of codified and tacit knowledge	Strengthens centrifugal forces	It becomes easier to exchange and transfer codified knowledge
	Strengthens centripetal forces	The ratio of tacit to codified knowledge might increase.
Reduction in control and management costs	Weakens or do not change centripetal forces	ICT is not a necessary and sufficient condition in itself, it also requires face-to-face contact
Increase in the cost of time in transit	Strengthens centripetal forces	The marginal value of time increases: the desire to be closer to the market increases
Reduction in the costs of commuting	Strengthens centrifugal forces	One of the major limits to urban growth in industrial cities is weakened
Reduction in the costs of replicating a product	Strengthens centripetal forces	Increases the degree of increasing returns
Reduction in the costs of relocation	Weakens lock-in effects	Increases the possibility of relocating once the conditions have changed

Table 1 above shows that the increasing use of ICT in business has many counterbalancing effects on centrifugal and centripetal forces. Therefore, the question of the final spatial impact of ICT has no definite answer at the theoretical level and it must therefore be addressed at the empirical level.

Available empirical evidence is discussed below.

2. Empirical evidence

There is ample agreement that the ICT and digital industries are geographically concentrated.

Le Blanc (2000) uses US data and finds that the most recent and fast-growing industries – Internet on-line services and software – exhibit a higher level of geographical concentration than four other industries[1] which, on the contrary, show roughly similar concentration measures. His research would tend to conclude that agglomeration forces are stronger in the Internet and software industries. Similar findings are reported by other researchers looking at a wide variety of industries and locations. Cooke (2002) discusses the formation and life of a wide variety of "knowledge" clusters: from biotech companies in Cambridge, UK, Germany or San Diego, US, to advanced opto-eletronics cluster in St Asaph, Wales; to the ICT cluster in Oulu, Finland. Quah (2001a) documents that successful regional clusters tend to cross national borders within the EU. Scott (1996, 1997, 1998), drawing on trade directories and official data, has studied the locational patterns of the multimedia industry in South California. He finds evidence of a strong spatial pattern in the industry: entertainment activities cluster in Los Angeles while business-oriented activities cluster in San Francisco. Sandberg (1998) has noted a similar concentration in Sweden, around Stockholm. Zook (2000) has used Internet registration data to provide maps of "dot.com" addresses across the US. He finds that "dot.com" activity is spread widely but unevenly across and within US city regions. Gillespie *et al* (2001) use trade directories to map the regional patterns of firms in the "New Media" subsectors (games, web-based advertising, etc.) showing that such activities are predominantly concentrated in four locations quite close to each other: London, the M4 Corridor, East Sussex and the M11 Corridor. Dodge and Kitchen (2000) obtain a similar picture using registered addresses of owners of domain name space in the UK. Similarly, Bonaccorsi *et al* (2002) find that domain names are more spatially concentrated across Italian provinces than income or population.

The foregoing empirical evidence has often been used to generalise (Cooke, 2002) and argue that new technologies will further reinforce existing regional imbalances: "The e-economy maps on to the existing geography of economic and social division." (Christie and Hepworth, 2001, p 141).

We believe this conclusion to be too hasty : the existence of spatial clustering of digital activities is not sufficient to surmise that ICT is leading to a more unequal landscape.

In Section 3 and 4 below we investigate this point further.

Following Dumais, Ellison and Glaeser (1997) and Kolko (2001) it is useful at this point to distinguish between two closely related but distinct concepts: concentration and convergence. Concentration refers to the clustering of an industry in one space at a specific point in time. Convergence refers to the tendency of one industry to become more uniformly distributed over space, i.e. to grow faster where initially under-represented. Dumais, Ellison and Glaeser (1997) show that changes in industrial concentration over time can be decomposed into convergence and random shocks. As a result, industrial concentration can be the current manifestation of past large random shocks and sufficiently slow convergence or of infinite small random shocks and divergence.

In Section 4 we look at concentration, Section 5 looks at convergence.

3. Industrial concentration in Italy

This Section analyses industrial concentration patterns across Italian provinces with the objective of understanding whether and to what extent localisation patterns of ICT and related activities are different from those of more traditional activities.

[1] The other sectors being cable, telecom, data processing and computer systems.

4.1 The data

We use data for *employment* from the Censuses of Industry and Services for 1981, 1991 and 1996. Employment data are aggregated by 82 industries (using the same classification used in the Input-Output Italian Table of 1992) and 103 provinces. We use employment data by establishment (site or plant where business is conducted), more appropriate than employment data by firm (one firm might include any number of establishments or activities) to analyse industrial locational patterns. Employment data by establishment are classified according to the activity of the establishment.

4.2 The results

We measure the concentration of industries using the Gini coefficient. The Gini coefficient, originally developed to measure the degree of income inequality in a population, has been adjusted to be used to measure the extent to which an industry is unequally represented across regions (Krugman, 1991). In this version, it is usually referred to as *Industrial Gini Coefficient* (see also Midelfart et al 2001, Amiti M, 1999). The value of the Gini ranges between 0 and 1. If all provinces have the same amount of a given industry, the Industrial Gini coefficient for that industry is zero. If the industry is represented in just one province, the Industrial Gini coefficient for that industry is equal to 1.

[Table 2 and Table 3 APPROX HERE]

Table 2 and Table 3 compare industries according to the level (1991) and change (1991-1996) of concentration, respectively for manufacturing and service industries.

Table 2 and Table 3 are constructed as follows: firstly, we have ranked the industries according to their concentration index and have indicated the top third most concentrated industries in the top-left corner (from the most to the least concentrated) and the bottom third or least concentrated in the bottom-left corner (again, from the most to the least). Residual industries are shown at the bottom of the tables. Then we have ranked each of the two groups according to the change in the concentration index and have reported respectively in the top-right corner those industries (among the group of most concentrated) which showed the biggest negative change (from the biggest negative change to the smallest) and in the bottom-left corner those industries (among the group of least concentrated) which showed the biggest positive change (from the biggest positive change to the smallest). In order to check for the longer term stability of these trends, we have indicated in italics the industries that would not have been in the same corner if the period 1981-1996 had been used.

Stars indicate whether the industry is ICT or ICT-intensive: three stars indicate an ICT industry, two stars indicate a percentage of intermediate inputs from ICT industries greater than 10%, one star indicates a percentage of intermediate inputs from ICT industries greater than 5%. They are all in bold.

Table 2 shows the manufacturing industries. Indeed, ICT-producing manufacturing industries appear in the top-left corner of the table (most concentrated), which may account for some of the evidence discussed in Section 3. However, it is also true that more traditional industries such as shoes, textile, jewellery and rubber products, which are at the core of some famous Italian "distretti industriali", also represents an important fraction of the group[2]. Besides, ICT-producing industries are the industries which are deconcentrating faster (top-right corner).

[2] Similar results are reported in Midelfart et al (2001), comparing industrial concentration across EU member states, where the most concentrated industries include

Table 3 shows the service industries. Here, we have a similar representation of ICT-intensive industries in the top-right and bottom-right corners of the table. If we look at ICT-producing industries (telecoms and software), they are both in the residual group. They are close to the top, which again may account for some of the evidences discussed in Section 3, but this is not definitely a major feature. Looking at the left column (changes), two ICT-intensive industries are deconcentrating and one is concentrating.

Overall, the intensive use of ICT does not appear to be the key characteristic to explain the ‘digital clusters’ (Silicon Valley or St Asaph, Oulu or the M4 corridor), which have attracted so much attention in current literature. Simple comparative analysis of industrial concentration such as that of Table 2 and 3 are not able to provide any clear cut reading of likely patterns of industrial localisation in the future digital economy.

Beyond ICT-intensity, industries characterising the so-called ‘digital clusters’ share at least three additional features: they employ a skilled workforce, they are knowledge- intensive and they are fastgrowing.

In the next section we discuss how these features might affect patterns of industrial localisation and we apply an econometric model to isolate the impact of ICT.

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textiles, clothing or footwear and in Krugman (1991) who describes geographic concentration in activities as diverse as carpet manufacturing, jewellery production, or the rubber processing industries.

4. Industrial convergence in Italy

In this Section we explain industrial locational dynamics in terms of the set of industry characteristics discussed above. The objective is to isolate the effect of ICT-intensity from other industry-characteristics.

4.1 The model

The basic equation (Kolko, 2001) is as follows:

$$Y_{ik} = \alpha + \lambda E_{ik} + \beta s_{ik} + \sum_m \delta_m (s_{ik} * B_{im})$$

where:

Y_{ik} = employment growth over the period 1991-1996 in the industry i in province k. Following Kolko (2001), local employment growth is calculated using the average of the start-year and end-year employment as the denominator to avoid having nul values (see Davis, Haltiwanger and Schuh, 1996);

E_{ik} = employment in province k, excluding industry i (province size);

s_{ik} = share of province k in total employment of industry i at the beginning of the period;

B_{im} = value of industry-characteristic B_m in industry i. Industry-characteristics do not vary across provinces[3].

The coefficient β detects whether there is geographical convergence or divergence. A ***negative*** $\boldsymbol{\beta}$ implies convergence: industries are growing faster where they are under-represented, and slower where they are over-represented.

The coefficients δ_m on the interaction terms $(s_{ik}*B_{im})$ are the critical ones: each δ_m identifies the effect of the industry-characteristic m on the speed of convergence. A ***negative*** $\boldsymbol{\delta_m}$ implies that the characteristic m is associated with faster-than-average convergence.

Below, we discuss the expected signs of the coefficients δ_m on the interaction terms relative to the following industry-characteristics:

- *ICT-intensity*. As discussed in Section 1, the effect of ICT on localisation depends on many counterbalancing effects. We therefore can formulate no *a priori* expectations on the sign of the coefficient δ on this interaction term;
- *industry growth*. Krugman (1991) suggests that young industries characterised by fast growth in the start-up phase are characterised by slower convergence. Opposite arguments are suggested by Dumais, Ellison and Glaeser (1997), who find that establishment births and expansions are more rapid outside areas of industrial concentration, implying that growing industries converge faster (Kolko, 2001). Depending on the relative strength of these two forces we might expect both a positive or negative coefficient δ on this interaction term;
- *skill-intensity* and *R&D-intensity*. Skill-intensity and R&D-intensity are used to proxy the *knowledge content* of industries. High-skill and R&D-intensive industries are expected to concentrate faster with respect to other industries: as they rely more on knowledge, ideas,

[3] This is not true for national industry growth (see Section 4.2 below).

and skilled labour, we expect powerful agglomeration forces, related to labour pooling and knowledge spillovers, to be at work here. We therefore expect a positive coefficient δ on this interaction term;

- *service industries.* Services might show different clustering dynamics from other sectors of the economy and are therefore controlled for in the regressions with a dummy variable. In many cases, the transportability of service products is lower than that of manufactured products and most services are much less clustered than manufacturing industries. However, this picture has been changing recently. Liberalisation and industrial restructuring in some services (banking for example, where big national banks have increasingly taken over most of the smaller regional banks) seems to have fostered concentration. We therefore expect a positive coefficient δ on this interaction term.
- *ICT-intensive services*. Concerning ICT in particular, Kolko (2001) suggests that ICT should free services from being located closer to the customers. Therefore, assuming that consumers are less concentrated than production, ICT-intensive services should show slower convergence than the rest of services. We control for this effect by further interacting the services interaction term with the ICT-intensity measure. Following from above, we expect a positive coefficient δ on this interaction term [4].

The specification of the model also includes both industrial and province dummies and a size variable. Results are therefore cleaned up from any nation-wide industry-specific or economy-wide region-specific effects and only refer to specific local industrial effects.

We deal with potential heteroskedasticity using both weighted regressions (using province populations as weight) and robust standard errors. Results from weighted regressions tend to be stronger in statistical terms, but they distort point estimates. We therefore prefer the results based on robust standard errors estimates, reported in Table 5-7. Table 8 shows that results are very similar when weighted regressions are used.

4.2 The data

The dependent variable, the province size, the national industry growth are constructed using the employment by establishment Census data described in Section 3. Province size is defined as employment in the province *k,* excluding industry *i*. National industry growth is defined the growth of industry *i* outside of province *k,* to avoid local industry growth (the dependent variable) included in the regressors.

Other industry-characteristics are constructed as follows.

We measure *ICT- intensity* in 4 alternative ways. The first measure is based on the Input-Output Table of 1992. ICT-intensity is measured by the share of ICT industries in industries' intermediate costs. This indicator measures the importance of ICT equipment and services in the cost structure of the sector. However, it does not capture what ICT is used for. We therefore have developed alternative measures, more closely related to the use of ICT for communication. The second and third measures are based on data from Current Population Surveys (CPS henceforth) of the US. The CPS is a monthly survey of American households conducted by the Census Bureau and the Bureau of Labour Statistics. Each individual is regularly asked for the level of education and the industry where he/she works. Every four years the CPS asks also for computer usage and, if so, for which tasks (including 'e-mail' or 'communication'). We measure ICT-intensity by the fraction of employees in the industry using a computer or e-mail at work in 1998. Industrial classification in the US slightly differs from the ISIC classification.

[4] However, Kolko (2001) found an unexpected negative coefficient on this term.

However, the differences existing between the two classification systems are minor and we believe they will not have altered the results. The fourth measure of ICT-intensity is a composite index of the previous three, which have been firstly normalised and then added together. Results are reported for the regressions making use of the first and last indicators only.

We measure *skill-intensity* alternatively as the share of non-manual workforce and the share of graduate workers in the industry. Both measures are based on the ISTAT Workforce Indicators for Industry and Services Big Enterprises, 1993. The second indicator seems more appropriate and gives better results in the regression analysis. We therefore report only the results based on this latter indicator.

Finally, we measure *R&D-intensity* in two alternative ways. Firstly, we use data on R&D expenditure by industry (average of 1996, 1997 and 1998) as a ratio to gross value added, factor costs. Data are from ISTAT, Indicatori Economici. Original data are for 36 industries. They have been expanded to 82 industries by applying the same share to all industries in the same group. This procedure, however, may cause a significant loss of information contained in the 82-industry original database. Besides, the available data refer to the period 1996-98 while beginning-of-period data might be more appropriate to avoid endogeneity problems. We have therefore developed a new measure based on the share of R&D industry in industries' intermediate output, and based on the 82 industries Input-Output Table of 1992. Details are in Appendix 2.

[Table 4 APPROX HERE]

Table 4 shows the correlations between the ICT, skill and R&D-intensity measures. Correlations are generally positive, implying that ICT-intensive industries are often also R&D and skill intensive. However, correlation coefficients are not too high, leaving space for statistical analysis. The two measures of ICT-intensity based on CPS data are very similar: if you use a computer you are very likely to use e-mail too. On the other hand, the two measures of R&D-intensity show surprisingly low correlation. We therefore can expect different results from the econometric analysis.

4.3 The results

We start the discussion of the results from a basic specification using the I/O-based measure of ICT-intensity and the R&D expenditure-based measure of R&D-intensity. Results are reported in Table 5.

[Table 5 APPROX HERE]

Regression 1 shows the results when only the share of province k in total employment of industry i at the beginning of the period is used as a regressor. The coefficient is negative and significant, implying that an overall process of convergence has been going on.

In Regression 2 we introduce the term interacting this share with our measure of ICT-intensity. The negative (and significant) coefficient implies that higher ICT-intensity leads to faster convergence. Kolko (2001) found a positive coefficient, but it became negative when other factors (growth profile, skill-intensity) were controlled for in the regression.

In Regressions 3, 4, and 5 we introduce, progressively, the interaction terms for industry growth, skill, and research-intensity. We found that the coefficient on the ICT interaction term remains negative and increases in absolute value, implying that the convergence effect of ICT is stronger when other factors are controlled for, consistent with Kolko, 2001. The coefficients on the industry growth and skill interaction terms are respectively negative and positive, as expected, implying that convergence is stronger in fast growing industries and slower in high-skill industries (again this result is consistent with Kolko's findings, 2001). The coefficient on

R&D interaction term is negative and significant. This result is opposite to our *a priori* expectations. We pursue the issue further below.

Regression 6 introduces the dummy for services interacted with the initial share and Regression 7 adds this term interacted with the ICT-intensity. The signs are positive, as expected, but not significant implying that there are not significant differences in convergence dynamics between non-service, service and ICT-intensive services industries.

Before further commenting these results, we carry out below some testing of their robustness. In particular, we estimate the model using alternative measures of ICT-intensity and R&D-intensity, we estimate it across subsets of industries and finally, we estimate the model using a different estimation technique. Results are in Table 6-8. The numbering of Regressions refers to the specifications adopted in Table 5.

Checking for alternative measures of ICT-intensity

The index of ICT-intensity used in Table 5 measures how much an industry buys in terms of ICT equipment and services, but it does not say why and for what purposes (see Section 4.2).

[Table 6 APPROX HERE]

Table 6 shows the results obtained when using the composed index of ICT-intensity, which takes into account the use of computer and e-mail by each industry's employees. The pattern of results is very similar to those in Table 5: using a different measure of ICT-intensity does not change the main results of previous analysis[5].

Checking for alternative measures of R&D-intensity

The measure of R&D-intensity used in Table 5 and Table 6 relies on original data with less sectoral detail than the dependent variable, implying the loss of potential important information (see Section 4.2). Column 1 to 3 in Table 7 report the equivalent of Regressions 5 to 7 in Table 6, using the measure of R&D-intensity based on the I/O Table (see Section 4.2 for details).

[Table 7 APPROX HERE]

Most of the previous results are confirmed. The only important change concerns the R&D term itself. The sign is now positive, implying that R&D-intensity is associated with faster divergence. The result is now in line with our *a priori*.

Checking for subset of industries and alternative estimation techniques

Column 4 and 5 in Table 7 shows the results of, respectively, Regression 5 and 7 when ICT-producing industries are excluded. The objective is to check for the impact of the adoption of ICT on localisation patterns of other sectors of the economy, independently from the ICT industries themselves. The coefficient on the ICT interaction term in Column 4 is higher than in the original regression estimated across all industries (Column 1). It implies that the convergence effect is stronger in other-than-ICT sectors than in ICT industries themselves. In Column 5 we introduce the dummies for services. The ICT interaction terms is no longer significant, while the ICT-interacted dummy is now significantly negative implying that, when we exclude the ICT industries, the ICT-convergence effect mainly comes through the service sectors.

The result is in line with Kolko (2001) but not consistent with our *a priori.* We expected ICT to free services from being located close to the consumers and therefore increase concentration (slowing down convergence). Apparently, this does not seem to be the only and most important

[5] The coefficient on the ICT term is smaller, but this is an effect of the different scale of the indicator itself the composite index , being the sum of three normalized indicators.

effect. Other mechanisms are probably at work. Firstly, inside the firm, ICT might allow a spatial re-organisation of the firms towards more cost-effective structures, as discussed in Section 2. The most preminent example is the relocation of back-office operations to low cost locations. Since our analysis is carried out on establishment-based employment data, this effect is likely to be quite strong. Secondly, looking outside the firm into its relationships with customers, it may be that the use of ICT, far from relaxing the need to stay close to custormers, is forcing firms to move the plants near customers in order to exploit local knowledge and networks, while allowing previously centralised operations to be carried out over the Internet.

The last two columns show the results of Regression 5 and 7 when only the 27 most ICT-intensive sectors are included. The size of the coefficient of the ICT term increases, implying a stronger convergence effect of ICT in the most ICT-intensive sectors. The explanatory power of regressions is also much higher: more than a quarter of variability of the dependent variable is now explained by the regressors. As we might expect, the stronger impact of ICT is where the ICT revolution is really taking place.

The results discussed above are confirmed when alternative estimation techniques are used. Table 8 shows the results of the same regressions of Table 7 when weighted regressions are used. Results are very similar to those reported in Table 7.

[Table 8 APPROX HERE]

5. Conclusions and implications for policy

The analysis above shows that the increasing penetration of ICT in the economy is leading to increasing convergence of industrial structure across Italian provinces: the more an industry is ICT-intensive, the more it tends to grow where it is under-represented. Results seem therefore to support the death-of distance view of the digital economy. ICT might indeed bring new possibilities for the Italian *Mezzogiorno*.

However, this is not the end of the story. Knowledge-intensity (as represented by R&D and skill-intensity) counterbalances the dispersion effect of ICT: the more an industry is knowledge-intensive the more it tends to grow where it is over-represented. This explains the emergence of big agglomeration of digital activities and seems to reconcile the 'death-of-distance' vision of the digital economy with the 'Silicon Valley' model.

Very similar results have been obtained by Kolko (2001), looking at industrial location patterns across US Standard Metropolitan Statistical Areas.

They have important implications for policy-making. A first implication concerns the elaboration of specific policies for the development of *Mezzogiorno* (and less advanced regions in general). Research results suggest that regional policies aimed at attracting low-knowledge functions (such as call centres) in ICT-intensive industries are likely to fail in creating new clusters, as agglomeration forces for ICT-intensive, low-knowledge activities are weak (Kolko, 2001). In this sense, "high-IT industries are unlikely to offer poorer countries long-term sustainable economic growth" (Kolko, 2001, p 18), as poorer countries and regions have stronger comparative advantage in low-skilled rather than high-skilled labour.

A more general implication concerns the regional impacts of the so-called Lisbon process. The adoption of the Lisbon strategy set the strategic objective for Europe to become "the most competitive *knowledge-based economy* in the world". The contemporaneous launch of the e-Europe Action plan recognises that ICT plays an essential role in this transformation. The shift towards a knowledge-based economy, as envisaged by the Lisbon process, compounds therefore two parallel but distinct shifts: a shift towards a more ICT-intensive economy and a shift towards a more knowledge-intensive economy.

Our result highlightsboth complementarities and trade-offs between the process launched in Lisbon and the objective of regional cohesion. On the one hand, as far as the ICT-dimension of the change is concerned, the empirical evidence seems to show that the increasing use of ICT in the economy will lead to greater dispersion of economic activity, i.e. less regional disparities. This would suggest that policies fostering the adoption of ICT by industries and regions would indeed favour a more geographically cohesive Europe.

On the other hand, there is evidence that the parallel shift towards more knowledge- and skill-intensive activities might counterbalance this dispersion effect. This implies a potential trade-off in European policies: the shift towards the knowledge-based European economy envisaged in Lisbon might result in less regional cohesion.

Two final considerations concern future research. First, an eventual clustering of ICT and knowledge-intensive industries does not automatically lead to a reinforcement of the traditional regional imbalances, such as the north-south Italian divide. If ICT and knowledge-intensive activities cluster in the periphery, this would rather contribute to the creation of a "multi-centric" landscape as envisaged in the European Spatial Development Perspective (EC, 1999). There is some evidence suggesting that this might actually be the case. Figure 2 shows that the Italian provinces most specialised in ICT are not in the traditional core. Similar patterns emerge at the European level where peripheral countries such as Finland, Ireland and Sweden are the countries most specialised in ICT and knowledge intensive production. More research is therefore needed to provide a more accurate picture of the clustering of knowledge-intensive activities.

Secondly, there is an increasing discussion about IPR rules, their impact on the share of codified-global to tacit-localised knowledge and their potential consequences on localisation (Quah, 2001b; Maignan *et al*, 2003). However, theoretical and empirical analysis is still at an early stage. We think this is an interesting area for new research.

Tables

Table 2: Manufacturing industries grouped according to the level and change of concentration

Most concentrated	*Most concentrated becoming less concentrated*
Costruzione aeromobili**	**Macchine per ufficio, sistemi informatici*****
Estrazione di combustibili liquidi e gassosi	**Apparecchi riceventi Radio-TV, registrazione suono ed immagine*****
Costruzioni navali**	*Fibre tessili artificiali*
Biciclette, motoveicoli, altri mezzi N.A.C.	Autoveicoli
Calzature	Lavorazione e conservazione di frutta e ortaggi
Macchine per ufficio, sistemi informatici***	**Costruzioni navali****
Apparecchi riceventi Radio, TV, registrazione suono ed immagine***	
Prodotti di oreficeria	
Fibre tessili e tessuti	
Autoveicoli	
Lavorazione e conservazione di frutta e ortaggi	
Strumenti ottici, apparecchi fotografici, orologi	
Prodotti farmaceutici	
Costruzione materiale rotabile	
Apparecchi per uso domestico N.A.C.	
Cuoio e articoli in cuoio	
Prodotti di cokeria e prodotti petroliferi	
Least concentrated	***Least concentrated becoming more concentrated***
Prodotti della chimica secondaria	Prodotti in legno
Confezione vestiario e pellicce	*Gas naturale e manifatturato*
Tabacco e bevande	Altri prodotti elettrici
Pasta carta e prodotti in carta	Altri prodotti metallici
Altre industrie manifatturiere	Recupero, preparazione per riciclaggio
Macchine industriali	Energia elettrica
Calce, cemento e gesso e loro manufatti	
Prodotti in plastica	
Editoria e prodotti della stampa	
Altri prodotti elettrici	
Apparecchi medicali e strumenti di precisione**	
Gas naturale e manifatturato	
Altri prodotti metallici	
Recupero, preparazione per riciclaggio	
Prodotti in legno	
Elementi da costruzione, cisterne, caldaie, generatori di vapore in metallo	
Energia elettrica	
Altri prodotti alimentari	
Residual	
Macchine agricole	
Prodotti della chimica primaria	
Prodotti in ceramica e terracotta	
Mangimi	
Acqua	
Componenti elettronici***	
Prodotti in gomma	
Prodotti siderurgici e metallurgici	
Lavorazione e conservazione di carni	
Articoli in tessuto e maglieria	
Pilatura, molitura di cereali ed altri prodotti amidacei	
Altri prodotti della lavorazione dei minerali non metalliferi	

<table>
<tr><td align="center">Apparecchi trasmittenti Radio-TV, telefonici e telegrafici
Prodotti in vetro
Estrazione di minerali
Motori e trasformatori elettrici
Mobili e strumenti musicali
Lavorazione e trasformazione del latte</td></tr>
<tr><td>Note(s): Three stars indicate an ICT industry, two stars indicate a percentage of intermediate inputs from ICT industries greater than 10%, one star indicates a percentage of intermediate inputs from ICT industries greater than 10%. They are all in bold.
In italics the industries that would not have been in the same corner if the period 1981-1996 had been used</td></tr>
</table>

Table 3: Service industries grouped according to the level and change of concentration

<table>
<tr><th>Most concentrated</th><th>Most concentrated becoming less concentrated</th></tr>
<tr><td>Trasporti marittimi e per vie d’acqua
Trasporti aerei
Ricerca e sviluppo**
Alberghi ed altri tipi di alloggio
Attività ausiliarie dei trasporti*
Trasporti merci interni
Agenzie viaggio ed operatori turistici*
Smaltimento rifiuti
Attività ausiliarie intermediazione finanziaria**</td><td>Attività ausiliarie intermediazione finanziaria**
Ricerca e sviluppo**
Trasporti merci interni</td></tr>
<tr><th>Least concentrated</th><th>Least concentrated becoming more concentrated</th></tr>
<tr><td>Trasporti ferroviari
Commercio dettaglio altri prodotti e riparazioni beni di uso domestico*
Manutenzione e riparazione autoveicoli
Commercio dettaglio non specializzato
Commercio all’ingrosso
Ristoranti ed altri pubblici esercizi
Servizi alle imprese*
Altri servizi
Commercio mezzi di trasporto, carburanti e riparazione motoveicoli*</td><td>Ristoranti ed altri pubblici esercizi
Servizi alle imprese*
Commercio mezzi di trasporto, carburanti e riparazione motoveicoli</td></tr>
<tr><th colspan="2">Residual</th></tr>
<tr><td colspan="2" align="center">Telecomunicazioni***
Software, servizi e manutenzione di prodotti informatici***
Attività ricreative, culturali e sportive
Poste e corrieri postali**
Commercio dettaglio specializzato alimentari
Locazione, attività immobiliari, noleggi
Assicurazioni e fondi pensione*
Intermediari del commercio*
Intermediazione monetaria e finanziaria**</td></tr>
<tr><td colspan="2">Note(s): Three stars indicate an ICT industry, two stars indicate a percentage of intermediate inputs from ICT industries greater than 10%, one star indicates a percentage of intermediate inputs from ICT industries greater than 10%. They are all in bold.
In italics the industries that would not have been in the same corner if the period 1981-1996 had been used</td></tr>
</table>

Table 4 Industry-characteristics: Correlation matrix

	Skill-intensity	R&D-intensity (R&D expenditure)	R&D-intensity (R&D Inputs from R&D I-O sector)	ICT-intensity (Inputs from ICT I_O sector)	ICT-intensity (PC use)	ICT-intensity (internet and e-mail use)	ICT-intensity composed
Skill-intensity	1	0.147	0.128	0.367	0.449	0.486	0.238
R&D-intensity (R&D expenditure)	0.147	1	0.024	0.583	0.386	0.432	0.843
R&D-intensity (R&D Inputs from R&D I-O sector)	0.128	0.024	1	0.071	0.110	0.111	0.470
ICT-intensity (Inputs from ICT I_O sector)	0.367	0.583	0.071	1	0.502	0.566	0.575
ICT-intensity (PC use)	0.449	0.386	0.110	0.502	1	0.962	0.478
ICT-intensity (internet and e-mail use)	0.486	0.432	0.111	0.566	0.962	1	0.521
ICT-intensity composed	0.238	0.843	0.470	0.575	0.478	0.521	1

Table 5: Regression results - basic specifications, robust standard errors

	Reg 1	Reg 2	Reg 3	Reg 4	Reg 5	Reg 6	Reg 7
	Coeff+	Coeff+	Coeff+	Coeff+	Coeff+	Coeff+	Coeff+
Industrial share in the starting year (YSTR)	-1,792*** (0,5270)	-1,2640*** (0,528)	-2,3662*** (0,5955)	-2,6739*** (0,5712)	-2,3250*** (0,5728)	-2,3733*** (0,5873)	-2,3981*** (0,5944)
Province Size	-0.004*** (0.001)	-0.003*** (0.001)	-0.003*** (0.001)	-0.004*** (0.001)	-0.004*** (0.001)	-0.004*** (0.001)	-0.004*** (0.001)
ICT-intensity * YSTR		-4,9482*** (1,5159)	-6,1829*** (1,8420)	-6,5227*** (1,8078)	-4,0124** (2,0127)	-4,0003** (2,0019)	-3,9019** (2,0119)
Skill-intensity * YSTR			20,6991** (9,9135)	22,4518*** (7,2670)	20,2336*** (6,8901)	21,3799*** (7,5107)	21,687*** (7,6066)
Industry growth * YSTR				-3,3482*** (1,4219)	-3,5828*** (1,4590)	-3,4090*** (1,5603)	-3,3643** (1,5569)
R&D-intensity * YSTR					-8,4150** (4,8347)	-8,4292** (4,8165)	-8,2733** (4,8299)
Dummy for services (DSER) * YSTR						0,3177 (0,8515)	-0,1084 (0,9573)
ICT*DSER*YSTR							-3,2929 (5,4585)
Constant	4,7691*** (1,6731)	3,8805*** (1,6042)	4,7426*** (1,3842)	5,0065*** (1,3423)	4,6219*** (1,3309)	4,8753*** (1,4353)	4,8630*** (1,4390)
N. obs	8050	8050	8050	8050	8050	8050	8050
R-squared	0,1602	0,1612	0.1619	0.1624	0.1627	0.1627	0.1627

Notes: *** = significant at 1%; ** = significant at 5%; * = significant at 10%;
+ = robust standard errors in parenthesis

Table 6: Regression results - ICT composed index, robust standard errors

	Reg 1	Reg 2	Reg 3	Reg 4	Reg 5	Reg 6	Reg 7
	Coeff+	Coeff+	Coeff+	Coeff+	Coeff+	Coeff+	Coeff+
Industrial share (YSTR)	-1,7921*** (0,5270)	-1,4589*** (0,5301)	-2,6259*** (0,6410)	-2,9655*** (0,6231)	-2,4148*** (0,6505)	-2,4456*** (0,6590)	-2,4491*** (0,6592)
Province Size	-0.004*** (0.001)	-0.003*** (0.001)	-0.003*** (0.001)	-0.003*** (0.001)	-0.003*** (0.001)	-0.003*** (0.001)	-0.003*** (0.001)
ICT-intensity * YSTR		-0,2230*** (0,0699)	-0,3144*** (0,0860)	-0,3428*** (0,0754)	-0,1822** (0,0960)	-0,1802** (0,0963)	-0,1723** (0,1040)
Skill-intensity * YSTR			21,8647*** (9,9575)	24,0769*** (7,2267)	20,5820*** (7,1752)	21,3362*** (7,8404)	21,3598*** (7,8790)
Industry growth * YSTR				-3,4970*** (1,3025)	-3,7011*** (1,3966)	-3,5787*** (1,5036)	-3,5464*** (1,5160)
R&D-intensity * YSTR					-10,0165*** (4,8069)	-10,0628** (4,7893)	-10,0959*** (4,8016)
Dummy for services (DSER) * YSTR						0,2216 (0,8342)	-0,0023 (0,9448)
ICT*DSER*YSTR							-1,7354 (5,5697)
Constant	4,7691*** (1,6731)	3,6523*** (1,6811)	4,3397*** (1,4512)	4,5568*** (1,3922)	4,3165*** (1,3263)	4,4961*** (1,4356)	4,5056*** (1,4454)
N obs	8050	8050	8050	8050	8050	8050	8050
R-squared	0,1602	0,1608	0.1616	0.1622	0.1626	0.1626	0.1626

Notes: *** = significant at 1%; ** = significant at 5%; * = significant at 10%;
+ = robust standard errors in parenthesis

Table 7: Regression results: I/O-based measure of R&D-intensity, robust standard errors

	Reg 5	Reg 6	Reg 7	Reg 5 NO ICT	Reg 7 NO ICT	Reg 5 Highest ICT	Reg 7 Highest ICT
	Coeff+	Coeff+	Coeff+	Coeff+	Coeff+	Coeff+	Coeff+
Industrial share in the starting year (YSTR)	-2,6825*** (0,5699)	-2,7275*** (0,5884)	-2,7492*** (0,5930)	-2,7453*** (0,5764)	-3,1050*** (0,6172)	-1,1506 (1,0433)	-1,2354 (1,1839)
Province Size	-0.004*** (0.001)	-0.004*** (0.001)	-0.004*** (0.001)	-0.004*** (0.001)	-0.004*** (0.001)	-0.002 (0.001)	-0.002 (0.001)
ICT-intensity * YSTR	-6,5417*** (1,8068)	-6,5341*** (1,7785)	-6,3541*** (1,7612)	-11,9255** (6,2482)	12,4243 (9,9105)	-8,4400*** (2,1335)	-8,4745*** (2,1863)
Skill-intensity * YSTR	22,4126*** (7,2361)	23,4764*** (8,0357)	23,8109*** (8,1127)	25,1722*** (8,1866)	21,7871*** (7,9626)	11,5865* (6,9253)	13,1823 (10,3019)
Industry growth * YSTR	-3,3961*** (1,4360)	-3,2345*** (1,5093)	-3,1781*** (1,5050)	-3,6304*** (1,5961)	-2,7126* (1,5925)	-4,4699*** (1,8331)	-4,2343** (2,1594)
R&D-intensity * YSTR	4,6132 (10,6083)	4,5198 (10,5747)	3,9560 (10,8195)	4,9606 (10,4855)	6,1299 (11,2029)	3,1516 (8,2583)	2,9504 (8,4056)
Dummy for services (DSER) * YSTR		-0,2936 (0,8324)	0,2277 (0,9831)		1,5396* (0,9776)		-0,4602 (1,8127)
ICT*DSER*YSTR			-4,0374 (5,6489)		-33,5952*** (12,5342)		0,7954 (6,7230)
Constant	4,7662*** (1,4305)	5,0059*** (1,5051)	5,0124*** (1,5119)	4,8253*** (1,4813)	4,4516*** (1,5608)	2,0497 (2,0677)	2,3670 (2,2115)
N obs	8050	8050	8050	7474	7474	2531	2531
R-squared	0,1624	0,1624	0,1625	0.1563	0.1568	0.2610	0.2610

Notes: *** = significant at 1%; ** = significant at 5%; * =significant at 10%;
+ = robust standard errors in parenthesis

Table 8: Regression results: I/O-based measure of R&D-intensity, weighted regressions

	Reg 5	Reg 6	Reg 7	Reg 5 NO ICT	Reg 7 NO ICT	Reg 5 Highest ICT	Reg 7 Highest ICT
	Coeff+	Coeff+	Coeff+	Coeff+	Coeff+	Coeff+	Coeff+
Industrial share in the starting year (YSTR)	-1,1138*** (0,2655)	-1,0384*** (0,2788)	-1,0462*** (0,2792)	-1,1870*** (0,2551)	-1,5069*** (0,2854)	1,1459** (0,6677)	1,4818** (0,6973)
Province Size	-0.003*** (0.001)	-0.002*** (0.001)	-0.002*** (0.001)	-0.002*** (0.001)	-0.002** (0.001)	-0.002* (0.001)	-0.001*** (0.001)
ICT-intensity * YSTR	-4,9108*** (0,6690)	-4,9118*** (0,6690)	-4,8327*** (0,6830)	-5,8445** (3,0773)	13,4165** (6,3831)	-7,0087*** (0,8815)	-7,1457*** (0,8994)
Skill-intensity * YSTR	15,1611*** (3,2324)	13,4805*** (3,7484)	13,5601*** (3,7511)	15,4221*** (3,5920)	11,3413*** (3,9131)	1,9171 (4,8650)	-3,5326 (5,8879)
Industry growth * YSTR	-3,4088*** (0,6406)	-3,6768*** (0,7085)	-3,3572*** (0,7094)	-3,7481*** (0,7068)	-3,3652*** (0,7845)	-3,8285*** (0,8575)	-4,7497*** (1,0074
R&D-intensity * YSTR	-0,1987 (7,2535)	-0,1453*** (7,2539)	-0,4296 (7,2709)	0,5098* (7,0417)	1,3723 (7,0469)	2,4508 (9,4124)	5,0723 (9,5874)
Dummy for services (DSER) * YSTR		0,4234 (0,4781)	0,6614 (0,6318)		1,3723*** (0,6625)		0,7942 (0,9497)
ICT*DSER*YSTR			-1,7510 (3,0389)		-26,2758*** (7,2081)		1,9700 (3,7138)
Constant	3,3286*** (1,1867)	2,9772*** (1,2513)	2,9849*** (1,2515)	3,0528*** (1,1676)	2,4420** (1,2081)	1,8299 (1,691)	0,6866 (1,8166)
N obs	8050	8050	8050	7474	7474	2531	2531
R-squared	0,1851	0,1852	0,1852	0,1877	0,1892	0,2822	0,2832

Notes: *** = significant at 1%; ** = significant at 5%; * =significant at 10%;
+ = robust standard errors in parenthesis

Appendix 2: The data

ISTAT, Censuses of Industry and Services for 1981, 1991 and 1996 is the main data source. Employment data are provided for 103 NUTS 3 regions (provinces) for the years 1981, 1991 and 1995 for the 82 industries in Table 9. The first two columns show industry codes and names in the original ATECO Classification. The ISIC correspondents are reported in the third column.

Table 9: The 82 Industries

ATECO Code	ATECO Name	ISIC correspondent
CA10, CA11, CA12	Estrazione di combustibili liquidi e gassosi	Extraction of crude petroleum and natural gas
CA13, CA14	Estrazione di minerali	Extraction of minerals
DA151	Lavorazione e conservazione di carni	Production, processing and preservation of meat
DA152, DA154, DA158	Altri prodotti alimentari	Manufacture of other food products
DA153	Lavorazione e conservazione di frutta e ortaggi	Production, processing and preservation of fruit and vegetables
DA155	Lavorazione e trasformazione del latte	Manufacture of dairy products
DA156	Pilatura, molitura di cereali ed altri prodotti amidacei	Manufacture of grain mill products, starches and starch products
DA157	Mangimi	Manufacture of prepared animal food
DA159, DA160	Tabacco e bevande	Manufacture of tobacco and beverages
DB171, DB172, DB173	Fibre tessili e tessuti	Spinning, weaving and finishing of textiles
DB174, DB175, DB176, DB177	Articoli in tessuto e maglieria	Manufacture of knitted and crocheted fabrics and articles
DB18	Confezione vestiario e pellicce	Manufacture of wearing apparel; dressing and dyeing of fur
DC191, DC192	Cuoio e articoli in cuoio	Tanning and dressing of leather; manufacture of luggage, handbags, saddlery and harness
DC193	Calzature	Manufacture of footwear
DD20	Prodotti in legno	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
DE21	Pasta carta e prodotti in carta	Manufacture of paper and paper products
DE22	Editoria e prodotti della stampa	Publishing, Printing and service activities related to printing
DF23	Prodotti di cokeria e prodotti petroliferi	Manufacture of coke, refined petroleum products and nuclear fuel
DG241, DG242	Prodotti della chimica primaria	Manufacture of basic chemicals
DG243, DG245, DG246	Prodotti della chimica secondaria	Manufacture of other chemical products
DG244	Prodotti farmaceutici	Manufacture of pharmaceuticals, medicinal chemicals and botanical products
DG247	Fibre tessili artificiali	Manufacture of man-made fibres
DH251	Prodotti in gomma	Manufacture of rubber products
DH252	Prodotti in plastica	Manufacture of plastic products
DI261	Prodotti in vetro	Manufacture of glass and glass products

DI262, DI263, DI264	Prodotti in ceramica e terracotta	Manufacture of other non-metallic mineral products
DI265, DI266, DI267	Calce, cemento e gesso e loro manufatti	Manufacture of other non-metallic mineral products
DI268	Altri prodotti della lavorazione dei minerali non metalliferi	Manufacture of other non-metallic mineral products
DJ27	Prodotti siderurgici e metallurgici	Manufacture of basic metals
DJ281, DJ282, DJ283, DJ284, DJ285, DJ286	Elementi da costruzione, cisterne, caldaie, generatori di vapore in metallo	Manufacture of structural metal products, tanks, reservoirs and steam generators
DJ287	Altri prodotti metallici	Manufacture of other fabricated metal products
DK291, DK292, DK294, DK295, DK296	Macchine industriali	Manufacture of general purpose machinery
DK293	Macchine agricole	Manufacture of special purpose machinery (agriculture)
DK297	Apparecchi per uso domestico N.A.C.	Manufacture of domestic appliances n.e.c
DL300	Macchine per ufficio, sistemi informatici	Manufacture of office, accounting and computing machinery
DL311	Motori e trasformatori elettrici	Manufacture of electric motors, generators and transformers
DL312, DL313, DL314, DL315, DL316	Altri prodotti elettrici	Manufacture of other electrical equipment n.e.c.
DL321	Componenti elettronici	Manufacture of electronic valves and tubes and other electronic components
DL322	Apparecchi trasmittenti Radio-TV, telefonici e telegrafici	Manufacture of television and radio transmitters and apparatus for line telephony and line telegraphy
DL323	Apparecchi riceventi Radio-TV, registrazione suono ed immagine	Manufacture of television and radio receivers, sound or video recording or reproducing apparatus, and associated goods
DL331, DL332,DL333	Apparecchi medicali e strumenti di precisione	Manufacture of medical appliances and instruments and appliances for measuring, checking, testing, navigating and other purposes, except optical instruments
DL334, DL335	Strumenti ottici, apparecchi fotografici, orologi	Manufacture of optical instruments and photographic equipment, watches and clocks
DM34	Autoveicoli	Manufacture of motor vehicles
DM354, DM355	Biciclette, motoveicoli, altri mezzi N.A.C.	Manufacture of bicycles, motor vehicles and others n.e.c.
DM351	Costruzioni navali	Building and repairing of ships and boats
DM352	Costruzione materiale rotabile	Manufacture of railway and tramway locomotives and rolling stock
DM353	Costruzione aeromobili	Manufacture of aircraft and spacecraft
DN361, DN363	Mobili e strumenti musicali	Manufacture of furniture and musical instruments
DN362	Prodotti di oreficeria	Manufacture of jewellery and related articles
DN364, DN365, DN366	Altre industrie manifatturiere	Other manufacturing n.e.c.
DN371, DN372	Recupero, preparazione per riciclaggio	Recycling
E401	Energia elettrica	Production, transmission and distribution of electricity
E402	Gas naturale e manifatturato	Manufacture of gas; distribution of gaseous fuels through mains
E401, E403	Acqua	Collection, purification and distribution of water
F	Costruzioni	Construction
G501, G503, G504, G505	Commercio mezzi di trasporto, carburanti e riparazione motoveicoli	Sale, maintenance and repair of motorcycles and related parts and accessories

G502	Manutenzione e riparazione autoveicoli	Maintenance and repair of motor vehicles
G511	Intermediari del commercio	Wholesale on a fee or contract basis
G512, G513, G514, G515, G516, G517	Commercio all'ingrosso	Wholesale trade and commission trade, except of motor vehicles and motorcycles
G521	Commercio dettaglio non specializzato	Non-specialized retail trade
G522	Commercio dettaglio specializzato alimentari	Retail sale of food, beverages and tobacco in specialized stores
G523, G524, G525, G526, G527	Commercio dettaglio altri prodotti e riparazioni beni di uso domestico	Other retail trade of new goods and repair of personal and household goods
H551, H552	Alberghi ed altri tipi di alloggio	Hotels; camping sites and other provision of short-stay accommodation
H553, H554, H555	Ristoranti ed altri pubblici esercizi	Restaurants, bars and canteens
I601, I602, I603	Trasporti ferroviari	Transport via railways
I631	Trasporti merci interni	Other land transport
I611, I612	Trasporti marittimi e per vie d'acqua	Water transport
I621, I622	Trasporti aerei	Air transport
I633, I634	Agenzie viaggio ed operatori turistici	Supporting and auxiliary transport activities
I632	Attività ausiliarie dei trasporti	Activities of travel agencies
I641	Poste e corrieri postali	Post and courier activities
I642	Telecomunicazioni	Telecommunications
J651, J652	Intermediazione monetaria e finanziaria	Financial intermediation
J660, J672	Assicurazioni e fondi pensione	Insurance and pension funding
J671	Attività ausiliarie intermediazione finanziaria	Activities auxiliary to financial intermediation
K701, K702, K703, K711, K712, K713, K714	Locazione, attività immobiliari, noleggi	Real estate, renting and business activities
K721, K722, K723, K724, K725, K726	Software, servizi e manutenzione di prodotti informatici	Computer and related activities
K731, K732	Ricerca e sviluppo	Research and development
K741, K742, K743, K744, K745, K746, K747, K748	Servizi alle imprese	Other business activities
O900	Smaltimento rifiuti	Sewage and refuse disposal
O921, O922, O923, O924, O925, O926, O927	Attività ricreative, culturali e sportive	Recreational, cultural and sporting activities
O930	Altri servizi	Other service activities

R&D-intensity

1. Ratio of R&D expenditure to gross value added, by industry. Data from ISTAT, national accounts.

2. Share of R&D inputs in total intermediate costs. Data from ISTAT, Input-Output Total Transaction Tables of 1992.

ICT-intensity

1. Share of ICT inputs in intermediate costs. Data from ISTAT Input-Output Total Transaction tables of 1992.

2. Share of workers using computer in total industry employment. Data from US Census Population Survey.

3. Share of workers using e-mail in total industry employment. Data from US Census Population Survey.

Skill-intensity

1. Share of non manual workers in total employment. Data from ISTAT Workforce Indicators for Industry and Services Big Enterprises, 1993 and 1996.

2. Share of non manual workers in total employment. Data from ISTAT Workforce Indicators for Industry and Services Big Enterprises, 1993 and 1996.

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